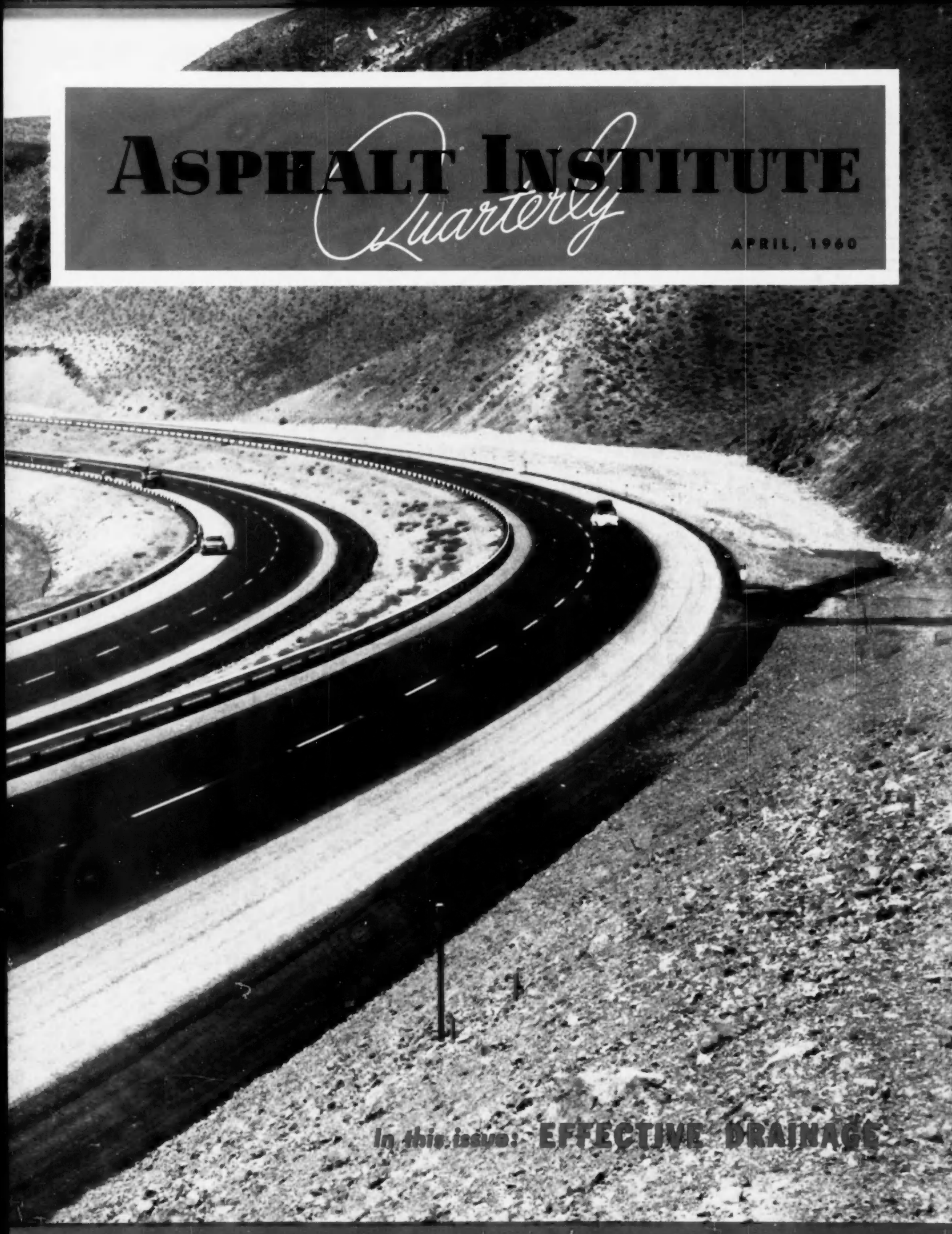
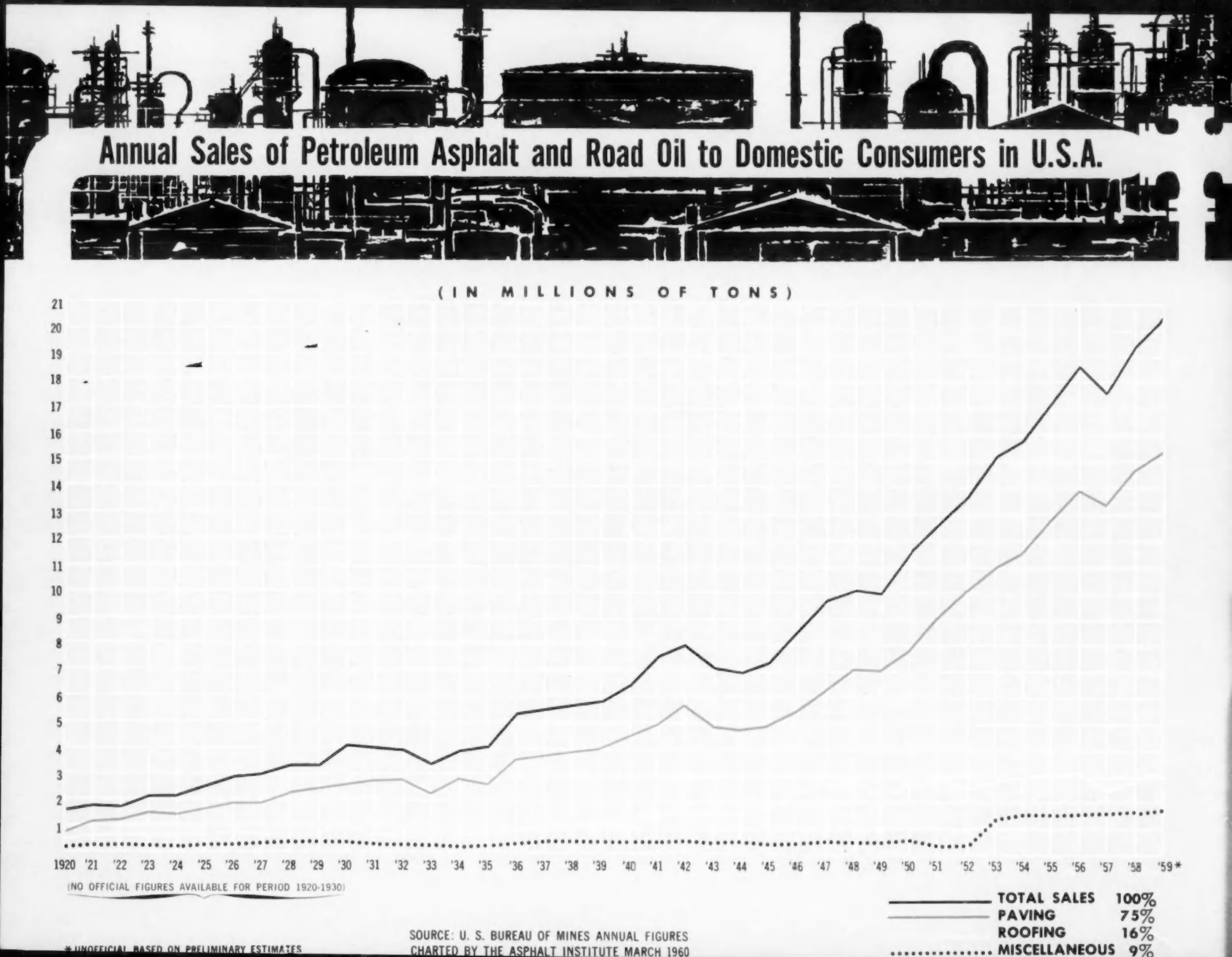
Asphalt Institute Quarterly

APRIL, 1960



In this issue: EFFECTIVE DRAINAGE

Annual Sales of Petroleum Asphalt and Road Oil to Domestic Consumers in U.S.A.



ASPHALTOPICS

Winning Combination: History of a sort was made by the January issue of the *Quarterly* when, for the first time, we had to go back on the press for an additional run to meet the demand. Fred Kimble's article on compaction attracted a lot of favorable comment, but the most interesting bulk order came from the Delaware State Highway Department which found a special use for the article on that state's ambitious all-the-way paving program. Chief Right-of-Way Agent H. L. Keene, arming his field people with *Quarterlies*, reported that the article would help negotiators explain highway needs to property owners.

Somehow we don't usually think of 85-100 penetration asphalt as being an instrument of policy in colonial government, but that's the way it works out in Algiers. After the Algerian rebels were dispersed, their cobblestone barricades were torn down and the stones replaced in the streets. Then a wary government, with a shrewd display of Gallic logic, sealed them beneath an overlay of asphalt concrete. C'est la guerre!

A note from Joe Draney, the patriarch of asphalt paving, recalls his first job in 1897—weighing out Trinidad lake asphalt from sailing vessels that used to poke their way up the Potomac River to the Washington refinery near Georgetown. Joe says he became enamored of road-building when, as a child on New Jersey Avenue in the District of Columbia, he watched the primitive paving operation when that street was asphalt-surfaced in 1884.

From an official of the duPont Company comes a chatty note, advising us that one of their lady stockholders recently wrote, asking details about a superior type of German road that she had heard about. Further, she wanted to know if duPont couldn't produce this "magic chemical" that was transforming Germany's beat-up autobahns into things of beauty and a joy forever. It finally turned out that the lady had learned second-hand about the asphalt resurfacing program that was reported in the October 1959 **Quarterly.**

NEW INSTITUTE PUBLICATIONS

Asphalt Mulch Treatment—Slim (12pp.) pocket-sized manual describing in simple narrative style the recommended procedure for using liquid asphalt in combination with straw and hay mulch to promote the growth of vegetation on slopes and flat areas subject to erosion. Manual Series No. 7.

Specifications for Asphalt Cements and Liquid Asphalts—12pp. revised edition of existing pamphlet, incorporating new material, including specification for asphalt cement for undersealing portland cement concrete. Specification Series No. 2.

The Story of Asphalt—A series of five articles published originally in the Christian Science Monitor in December, 1959, now collected and reprinted as a single, fascinating historical account of the development of asphalt technology. An excellent introduction to the subject for the layman. 8pp. Information Series No. 111.

ASPHALT INSTITUTE *Quarterly*

Vol. 12, No. 2 **April, 1960**

Glynn Harvey
Editor

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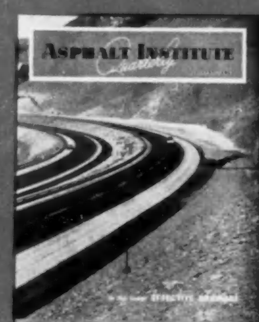
Cover

Completion of this four-mile section of asphalt-paved (2½ inches of asphalt concrete on four inches of hot-mix asphalt base) superhighway last August gave Nevada 22 miles of continuous Interstate mileage in the Truckee River canyon east of Reno.

—Nevada Dept. of Highways Photo



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The member companies of the Institute, who have made possible the publication of this magazine, are listed on page 15.

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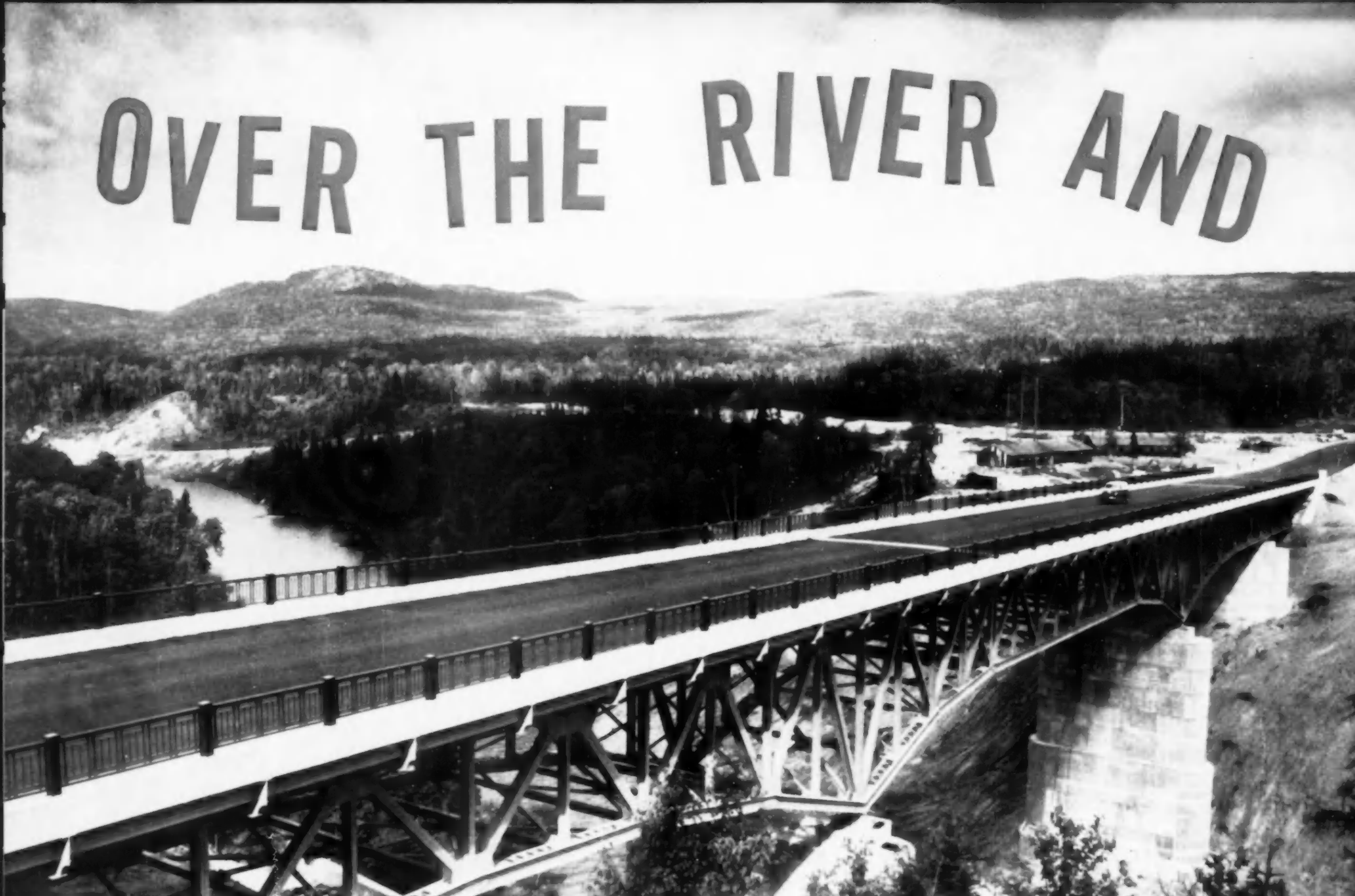

OVER THE RIVER AND


THROUGH THE WOODS

TRANS CANADA 1

LOST in the din of Interstate construction and obscured by the blizzard of U. S. road-building dollars, Canada is engaged in a road program of her own which, in some respects, is just a little more dazzling than the U. S. effort.

The Canadian provinces and the federal government at Ottawa are in the home stretch of a ten-year-old struggle to fling a single continuous strip of 24-foot-wide pavement across the continent—5,000 miles from St. Johns in Newfoundland to Victoria, B. C. When completed in another year or two, it will represent the longest unbroken stretch of highway ever built by one government agency in the history of the world.

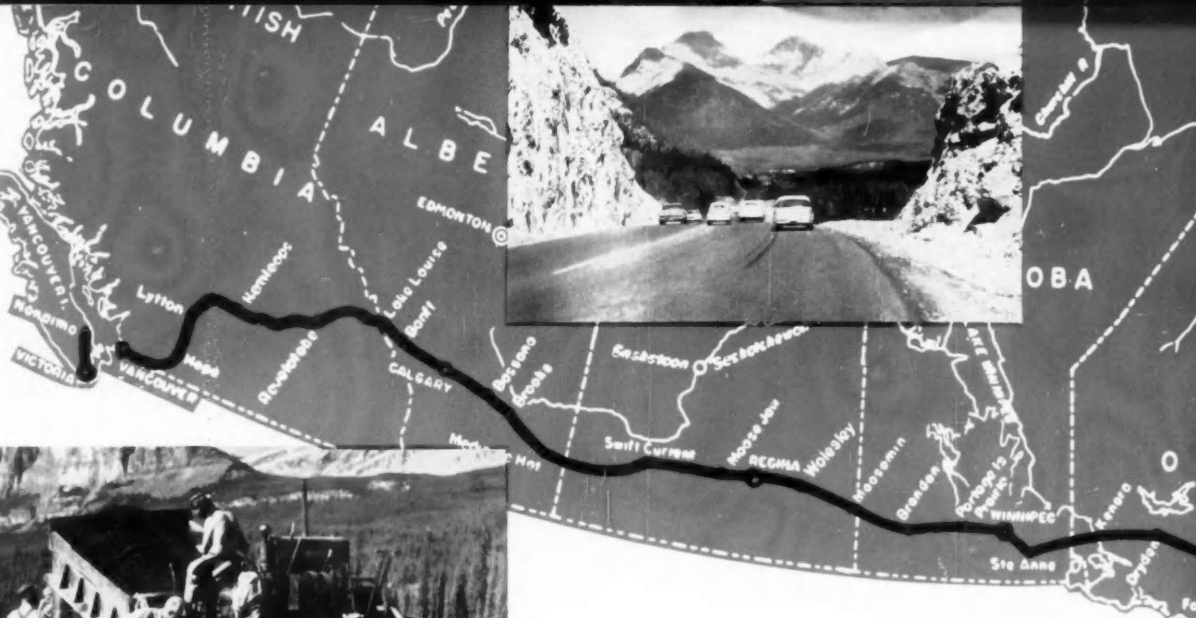
ANOTHER ASPHALT MONUMENT

These 5,000 miles (including some 500 miles of linking pavement in non-participating Quebec) are about 99 percent asphalt-paved. Scattered sections in four provinces have been constructed with rigid slabs, but general design criteria were drafted with asphalt paving in mind and, for all intents and purposes, the Trans-Canada Highway is another engineering monument to the remarkable adaptability of that pavement type.

Acid-tongued critics of the massive United States road program might profit by a thoughtful review of Canada's experience. After all, the Canadian government rolled up its sleeves and started moving earth on its big job back there in 1949, when the United States was still drafting reports and viewing its road problem with mounting alarm. Since that time, Canada has seen its early estimate of costs nearly double and has seen its original target date for completion of the project come and go.

As contemplated in the Trans-Canada Highway Act of 1949, the road was to have been finished in 1956. The

The Trans-Canada Highway is the longest single road-building project in history



First lift of three-inch asphalt concrete surface course is placed near Banff. Mount Eisenhower in background

cost was hiked to more than $500 million with the federal contribution climbing to more than $300 million. Perhaps it was a coincidence that, in 1956, both the Canadian and United States governments came up with a 90-10 sharing proposal to the states and provinces. But the Canadian parliament placed a firm lid on its offer. As an added incentive to the provincial governments to close conspicuous gaps in the route, Ottawa offered to increase its ante to ninety percent of the cost, but limited the offer to ten percent of the total mileage in each province.

Last year, another extension of time was voted with the hope that the last gap in the line will be closed in 1960, and paving completed in 1961. At this writing, about 1200 miles remain to be paved and only a few hundred miles remain to be placed under grading contract.

TWO BIG GAPS

There are two principal gaps remaining in the coast-to-coast highway. One is a 68-mile stretch of tumbling peaks and canyons laced by wild rivers around the northeastern rim of Lake Superior in Ontario. A little more than a year ago this gap stretched for 165 miles through howling wilderness from the Agawa River, 94 miles north of Sault Ste. Marie, to Marathon, a brand new town that has sprung up around a pulp mill. Clearing the required 100-foot right-of-way through this rugged country—considered as spectacular as anything in the Canadian Rockies—was a major lumbering operation. Rock removal and bridging cataracts pushed the cost of road-building in this section to $325,000 per mile.

Engineers are confident that 1960 will see this 68-mile gap closed, opening the route to travel on a graded gravel surface all the way around the northern shore of Lake Superior, through Ontario's high country.

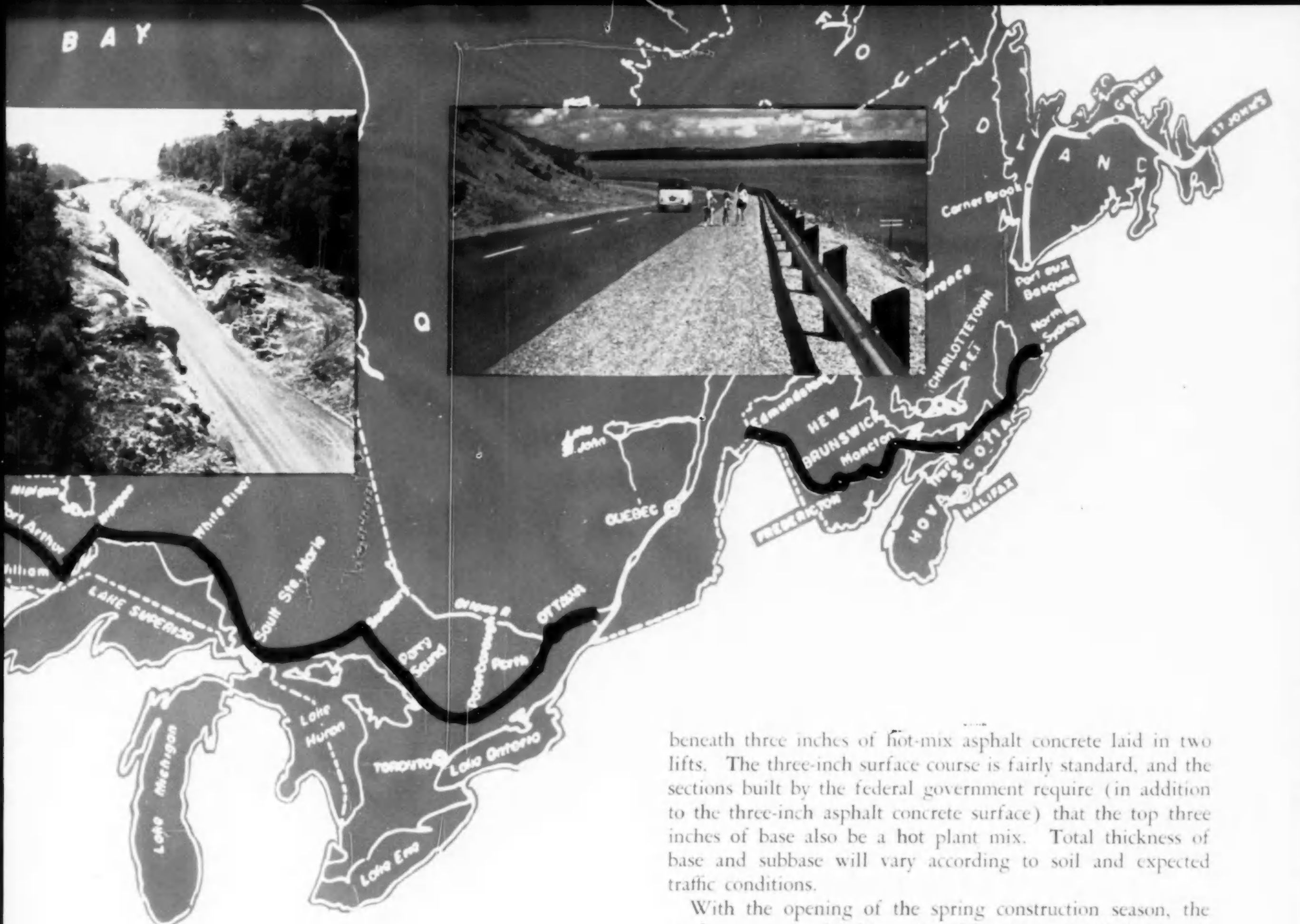
A second gap, and one shot through with special problems, is that stretch of road through four neighboring national parks on the Alberta-British Columbia border. Everyone, including the Canadian army and imported avalanche experts, have been getting into the act. In fact, even the truculent Canadian grizzly bears have been horning into the picture, sabotaging operations with a display of gastronomical virtuosity that deserves passing mention—and will receive it.

SHOOTING THE GAP

When the engineers laid out the route in this section, they had a choice of driving ahead for ninety miles through Rogers Pass in the Selkirk range, or following the water-level route that traces a 190-mile arc to the north, along the course of the Columbia River. The Canadian Pacific Railway already had tried threading the pass back in 1894, but snowslides and avalanches, thundering down from the majestic surrounding peaks, buried that dream. In 1916, the railroad gave it up as a bad job and started running its trains through the Connaught Tunnel which was drilled through the mountains.

In spite of this grim record, the road-builders decided to tackle the beeline route through the Pass again. The economic justification was clear in the face of the dreary alternative—a 100-mile detour along the river bottom. The engineers concluded that we have come a long way in the last 75 years in the knowledge of how to control snowslides.

Several methods are employed in this technique. Earth mounds, acting like World War II concrete tank traps, have proved effective in stalling and braking slides. Diverting dams also are used to steer slides away from the road and snow fences are proving effective in preventing the build-up of dangerous overhangs on the peaks. Canadian army teams, armed with mortars and other field pieces, have been bracketing the danger spots on the upper slopes and triggering threatening



slides prematurely with well-placed shots. The engineers plan to place heavy reliance also on several strategically located snow sheds which will protect traffic at vulnerable locations.

BLUE PLATE FOR BRUIN

One method, however, was abandoned by the avalanche experts. They tried planting dynamite charges on the upper slopes, to be set off when roving avalanche spotters recognized the danger symptoms. This didn't work, though, and an investigation explained why nothing happened when the powder monkeys hit the plunger. It seems roaming grizzly bears kept unearthing the dynamite sticks and devouring them like lollipops. Aside from a mild hyperacidity, the bruins apparently thrived on the diet.

A less dramatic, but costlier, problem was presented by the rugged terrain in this area. For example, construction of the 27 miles through Canada's Glacier National Park required the removal of ten million cubic yards of rock, an average of 370,000 cubic yards per mile. Yet, in this nightmare world of rock there is a dearth of suitable aggregates for base construction and surface mix. Limestone outcrops are being investigated to determine the feasibility of starting quarrying operations.

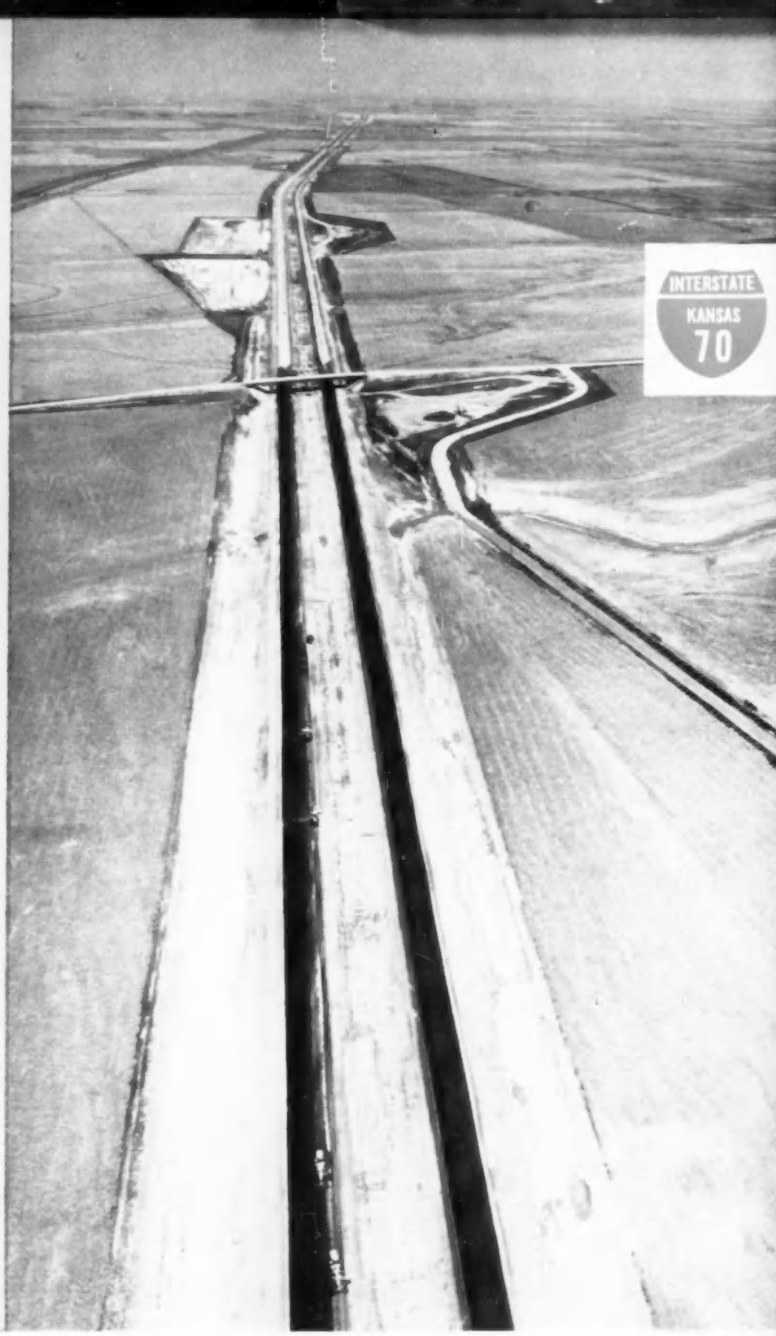
Total thickness of pavement on the Trans-Canada Highway varies with site conditions. However, the asphalt pavement layer is specified as three inches minimum. A typical section in British Columbia calls for 12½ inches of aggregate base beneath three inches of hot-mix asphalt concrete laid in two lifts. The three-inch surface course is fairly standard, and the sections built by the federal government require (in addition to the three-inch asphalt concrete surface) that the top three inches of base also be a hot plant mix. Total thickness of base and subbase will vary according to soil and expected traffic conditions.

With the opening of the spring construction season, the work crews on the Trans-Canada Highway will be under pressure to press for early completion of the project. The provinces and the federal government are anxious to get this herculean job out of the way so they can get on with a new and even more ambitious road program.

Next on the Canadian schedule is her "Roads to Resources" program, calling for the construction of more than 4,000 miles of new roads stretching off into the Canadian boondocks hitherto accessible only by plane or dog sled. These will not be superhighways; they will only be pioneer, all-weather roads. Paving will come later on these tiny tentacles of civilization, sometimes called "Roads With a Future."

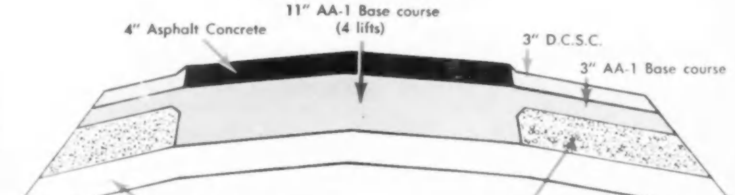
This stretch of the Trans-Canada Highway in British Columbia carries a traveler toward scenic grandeur of Canadian Rockies

IT TAKES KNOW-HOW AND KNOW-WHERE



Cut in pavement section for installation of an inlet box shows full depth of asphalt base on Kansas I-70 project

TYPICAL PAVEMENT SECTION



Typical roadbed cross-section showing heavy four-layer base, two-course paving, high-type shoulders and related features. Dual roadways here are 42 ft. c. to c.

Asphalt-base section is built on Kansas Interstate system by contractor who knew how to lick the aggregate shortage on the plains.

PARCHED by summer sun and scoured by winter storms, the Great Plains of western Kansas can break a man—particularly if he's a farmer or a road-builder. There sometimes isn't enough rainfall to sustain the former, and not enough road-building aggregates to suit the latter.

That's why, when the Kansas Highway Department invited bids last year to construct 22.628 miles of Interstate Route 70 in Trego County, it could have been an invitation to disaster for the unwary contractor.

FIRM WITH FORESIGHT

But the San Ore Construction Company of McPherson had the vision to anticipate the challenge in this part of the state, and the good sense to do something about it. As early as five years ago, the firm staked out a lease on the only important source of crushed stone in that part of Kansas. Ten years ago, the same firm had the foresight to recognize that Kansas sands are deficient in filler particles and took a long-term lease on a large sand pit which produces material which falls into the desirable minus 80 mesh classification.

In addition, the contractor did a good job of reconnaissance in west-central Kansas and was privy to the locations of numerous useful sand pits. Armed with know-how in sand-asphalt base construction and the necessary "know-where" for short-haul supplies of aggregates, San Ore was able to bid with confidence on the first asphalt section for the Kansas Interstate-Defense system.

Finally, and of critical importance, the San Ore crews were old hands at meeting the strict Kansas gradation specifications for this type of work and were experienced in laying sand-asphalt base.

ASPHALT BASE SPECIFIED

This section roughly parallels U. S. Route 40, bypassing the towns of Ogallah, Wakeeney and Collyer. The Highway Department, painfully aware of the aggregate shortage on the loamy plains, called for a road-mixed asphalt base design with an asphalt concrete surface—in effect, beefing up the locally available base materials of inferior quality and adding a heavy-duty asphalt surface of adequate thickness. This shrewd use of asphalt has been winning many engineering converts in those geographical areas afflicted with an aggregate deficiency.

This marriage of road-mixed sand-asphalt base to plant-mixed asphalt concrete surface is an old story in Kansas. It is a pavement design which has performed handsomely on state primary roads. Adapting the design to Interstate traffic meant simply beefing up the base thickness and tailoring the surface type to the need.

A typical design section for the I-70 pavement shows 11 inches of road-mixed asphalt base, using four percent MC-4 cutback after blending of base materials from windrows. The eleven inches of asphalt base were laid down on six inches of compacted subbase in four lifts, topped with four inches of hot-mix asphalt concrete applied in two courses. The top three inches of asphalt base mix was extended full width to provide a three-inch base for the shoulders which were surfaced with three inches of asphalt plant-mix.

MATERIAL PLACED IN WINDROWS

The base materials, carefully graded, were placed in windrows which were shaped and further blended by motor grader. The asphalt mixing train, straddling the windrow and moving at a rate of about one mile every four hours, applied the cutback and the mixture was aerated until the volatiles were reduced by about fifty percent.

Spreading of the windrow for each lift was performed with an electronically-controlled blade which already had proved itself in grading the roadbed to remarkably close tolerances. Base rolling was done with pneumatic-tire rollers, both self-propelled and tractor-drawn. Use of the subgrade and the compacted base courses as haul roads proved the stability of the foundation construction when, under this type of concentrated wheel loading, there was no evidence of rutting or displacement.

The project involved three separate but adjacent contracts involving 684,440 tons of base and surface aggregates and 3,643,677 gallons of asphalt. Total bid price was $3,171,485.43 for an average overall cost of $208,252 per four-lane mile. Cost of the 15-inch asphalt pavement was approximately $3.36 per square yard, exclusive of shoulders and ramps.

Base materials were windrowed and mixing was done by a mixing train which traveled at rate of a mile in 4 hours

Spreading of base materials was done by electronically-controlled blade for greater uniformity and smoothness

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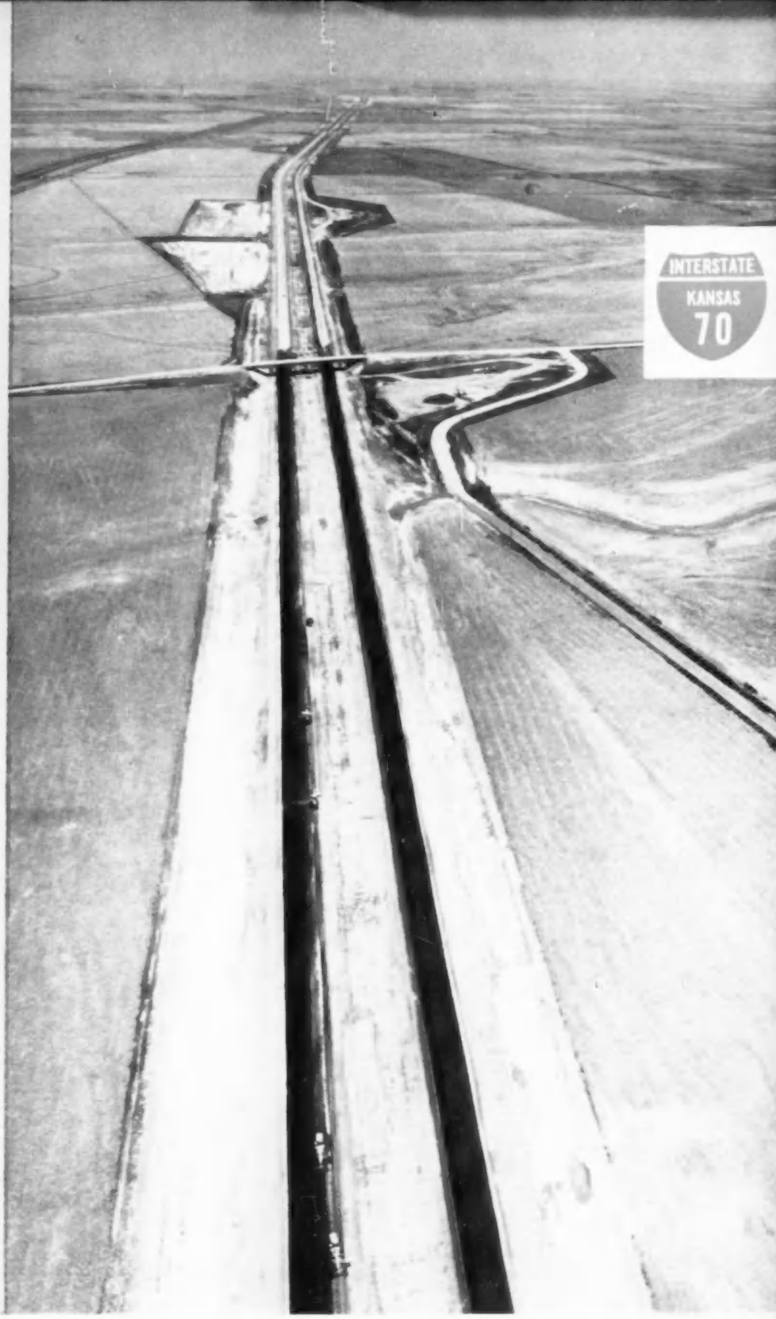

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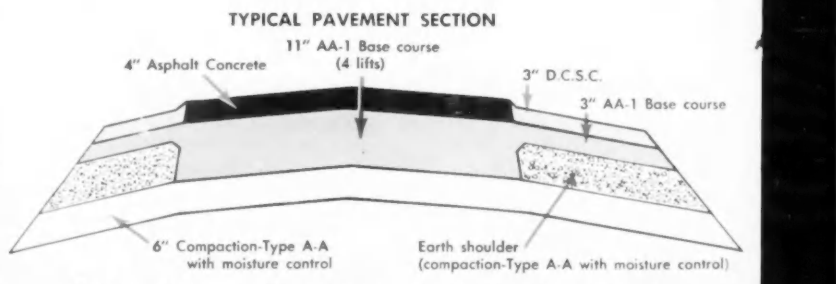

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Efficient FILTERING for Effective

A discussion of some important aspects

By W. R. Lovering
District Engineer—The Asphalt Institute
Sacramento, California

This article was presented by Mr. Lovering on March 2, 1960, as part of a panel discussion on "How Should Asphalt Pavement Sections Be Designed for Effective Drainage", held during the Third Annual Highway Conference at the College of the Pacific.

WITH the present trend toward elimination of side ditches and increase in lane width for driver safety, together with full paving of shoulders for greater structural support, the design of adequate drainage features in the pavement structural section has become a complex and demanding requirement of highway design. Consequently, the design and construction of these drainage facilities should no longer be treated as routine. Any drains installed must quickly and effectively remove all free water from the structural section and they must perform this function throughout the entire life of the highway. The problems encountered are, in many respects, approaching those of airport drainage.

All too frequently, when ground water seepage is encountered on a highway project, standard underdrains are installed without any special design, assuming that the underdrain will provide all the drainage required. Culverts for surface runoff are selected with care to provide the needed capacity, but the capacity of the subsurface drainage is scarcely considered. The grading of the filter material, the spacing of the underdrains, and the thickness of the filter blanket used, are all factors that must be analyzed and evaluated with due regard to the soil to be drained and the grades involved.

EVALUATE VARIABLES

These variables are, at best, difficult to analyze due to the seasonal fluctuation in the volume of seepage and variation in permeability with compaction. The variables involved must be evaluated, however, at least approximately, and the drainage designed accordingly, because inadequate drainage will result in a saturated foundation with loss of support. More important, a hydrostatic head may develop in the base sufficient to lift the pavement. A hypothetical example (Figure 1) will illustrate the principles involved:

If we assume a one-foot layer of filter material placed on a sixty-foot width of water-bearing soil with a 2% cross-slope toward an underdrain (hydraulic gradient of 0.02), and if we assume, further, a coefficient of permeability of ten feet per day for the filter material, each lineal foot of this installation will be capable of carrying approximately .37 cubic feet, or less than 3 gallons of water to the underdrain each day. A dripping faucet will produce a pint of water in 10 minutes, or 18 gallons in a day—six times as much water as would be removed by each lineal foot of underdrain conforming to the above conditions.

If the soil beneath the filter material has a coefficient of permeability of only .2 foot per day and a hydraulic gradient of 0.04, the amount of water trying to enter the filter material will be 0.48 cubic foot per day. This excess of .11 cubic foot per day gradually will increase the hydrostatic pressure beneath the pavement and if the pavement is relatively impervious, so that the water cannot escape, the pavement will be lifted and eventually broken by traffic. Actual examples of this have been noted where uplift has been sufficient to create a hazard to traffic.

A CONSERVATIVE EXAMPLE

The illustration cited is admittedly an oversimplification and a more accurate estimate of the hydraulic gradients may be made by the construction of a flow net. It is, however, a conservative example of what is occurring on many of our highways. The assumed conditions cover only what might occur with a uniform and relatively impervious soil. When we consider the possibilities of water-bearing strata of silty gravel or sand, the consequences are even more startling.

Before discussing possible solutions to the above problem, let us first consider the requirements of a satisfactory underdrain:

Shoulder cracking caused by water draining into fill slope

Water is shown here rising through the pavement on a fill

DRAINAGE

of highway drainage

1. It must have sufficient capacity to remove any free water from beneath the pavement. To do this the permeability of the underdrain must be several times the permeability of the soil which is to be drained.
2. It must maintain the same permeability throughout the design life of the pavement. To prevent clogging of the drain the filter material must have a grading sufficiently fine to prevent migration of silt particles into the drain from the adjacent soil.

The relative permeability of the materials involved can be determined accurately only by tests, although tests on remolded samples may also be misleading. A working procedure, based on the grading of the materials, was suggested by Terzagi for the selection of filter material gradings. This procedure has been tested and adopted, with certain modifications, by the Corps of Engineers. The criteria are based on the piping ratio determined by the relationship of the maximum size of the smallest 15% and the maximum size of the smallest 85% of both the soil and the filter material. The most important of these criteria are:

To prevent clogging of the filter material, the ratio of the 15% size of the filter material to the 85% size of the material to be drained shall not be greater than 5; and the ratio of the 50% size of the filter material to the 50% size of the material to be drained shall not be greater than 25.

To assure adequate capacity, the ratio of the 15% size of the filter material to the 15% size of the protected soil shall be at least 5.

STANDARD WORKING GRADINGS

The use of the Corps of Engineers' criteria requires the selection of a filter material grading for each installation, depending on the grading of the soil to be drained. This procedure is not practicable for contract bidding unless the requirements may be accurately determined well in advance. For this reason, the California Division of Highways has used standard filter material gradings. These standard gradings have been revised recently. They are much more open than those previously specified and the capacity should be adequate for any fine soils.

These standard gradings, however, while entirely satisfactory for normal conditions, may not be expected to fit all conditions and each installation should be given careful study and evaluation. This critical evaluation will, in most cases, have to be made during actual construction and will, therefore, depend on the alertness of the resident engineer.

Application of the Corps of Engineers' criteria to the new gradings may be of interest in illustrating the type of soil which may be drained most effectively by standard filter mate-

FIG. 1

$q = kT\frac{H}{D}$ = Peak discharge in Cu. Ft. per day per foot of drain.
k = Coefficient of permeability in feet per day.
H, T, and D are dimensions shown.

FIG. 2

U. S. CORPS OF ENGINEERS FILTERS CRITERIA APPLIED TO CALIFORNIA DIVISION OF HIGHWAYS FILTER MATERIAL

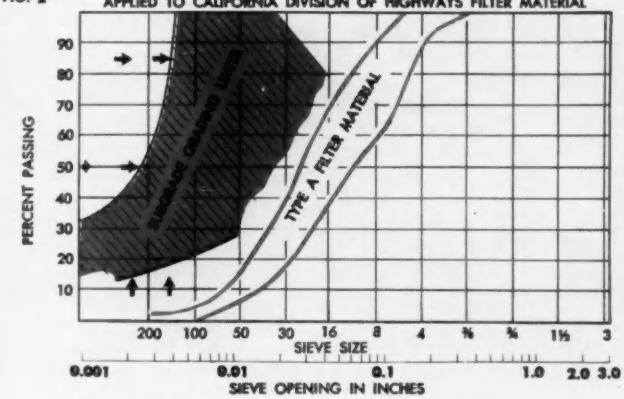
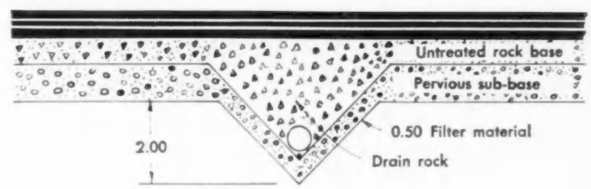


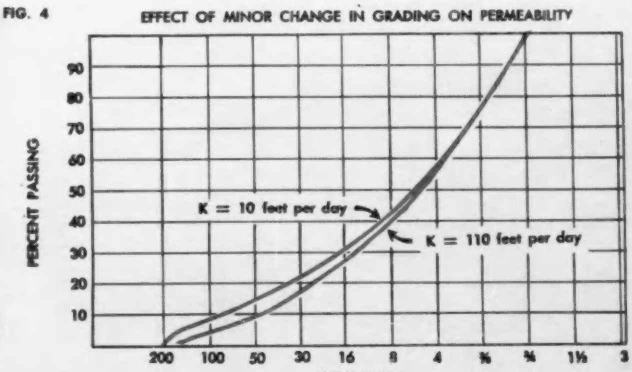
FIG. 3



TWO LAYER SYSTEM FOR HEAVY FLOW

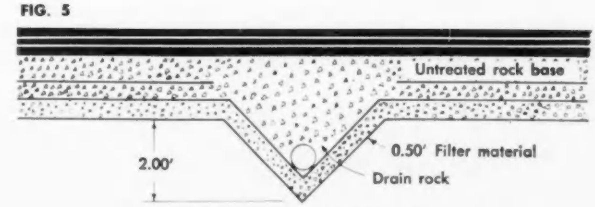
FIG. 4

EFFECT OF MINOR CHANGE IN GRADING ON PERMEABILITY



PLOTTED FROM TABLE 5 p. 256 PUBLIC ROADS FEB. 1952

FIG. 5



TWO LAYER SYSTEM FOR VERY HEAVY FLOW

rial gradings. It will be noted from Figure 2 that the Type "A" filter material will provide adequate capacity for a soil containing not less than approximately 15% passing the No. 200 sieve. Water-bearing clean sands or gravel will require a much more open grading. The use of a more open grading, however, will undoubtedly lead to clogging by fine soils which are normally interbedded or associated with the coarser water-bearing materials.

How, then, may we provide capacity adequate for the coarser, more open, water-bearing strata without running the risk of eventual clogging of the drain? We may

1. **Increase the thickness of the filter material. This would be equivalent to increasing the size of a culvert for surface drainage.**
2. **Use more closely spaced outlets to reduce the distance the water must travel.**
3. **Design a two-layer drainage system, in which a thin layer of filter material is used to prevent clogging, and a second layer of coarse, very open material is used to supply the drain capacity. This type of installation is illustrated in Figure 3.**

TWO-LAYER DRAINS URGED

Two-layer drains have been criticized as not being practical to build. There is no doubt that this type of drain will not be as easy to build as a drain using a single filter material and will also be more expensive, but the matter of practicality should be determined by the cost compared to the effectiveness of the drain. When we consider the cost of the pavement structure that may be lost through defective or inadequate subdrainage, there appears to be little doubt that the additional cost is justified if the drain is effective and prevents pavement failure. Some installations of this type already placed have shown them to be effective in handling larger volumes of seepage.

Finally, let us consider the importance of close inspection and control in the production of filter material. The permeability of the filter material can vary greatly with only minor variations in the grading, particularly in the fine sizes. Figure 4 shows the gradings of two materials, the coarser of which has a permeability 11 times that of the other, but the difference in the grading is only a few percent on the fine sizes. This data is taken from a report in the PUBLIC ROADS magazine for February 1952. The only difference in the two gradings is the elimination of the six percent of material between the #140 and #200 sieve.

Typical of California's attention to drainage features is this picture showing asphalt curbing and drainage flume

WHEN DRAINAGE FAILS

Considering this striking difference in permeability, it is not difficult to imagine what would happen on a long grade if the filter material were filled to capacity and there was a change in grading which materially reduced the permeability. The effect would be the same as placing a check or dam in a canal. An increase in head would result. The excess water would have to go off on the sides, rise through the pavement, or lift the pavement. Any of these possibilities is objectionable from the point of service of the pavement. Seepage water draining on to a fill slope can cause serious cracking of the fill slope and pavement. Uplift of the pavement may result in complete loss of the pavement structure.

The condition described above may be avoided by rigid control of filter material grading or by increasing the capacity of the drainage so that areas of minimum capacity will be adequate to meet the demands. Installation of cross-drains on grades at frequent intervals will generally be a more positive and economical solution. Cross-drains will provide an outlet for seepage water and, if properly designed and placed, prevent an excessive amount of water from accumulating in the void spaces of the previous drain material.

Cross-drains, to be completely effective, should be placed after the filter blanket and base material have been compacted and should cut completely across these layers. This is necessary because seepage water will frequently flow on top of a compaction plane developed during placing of the base material and, unless the cross-trench cuts this plane, the water will not enter the cross-drain. This is particularly true if the base aggregates have a tendency to degrade under traffic and produce additional fines.

Standard grading filter materials should be adequate for fine grained water-bearing soils but if water is entering through an open material, such as coarse sand or gravel, a special design must be used to provide the capacity required. (See Figure 5)

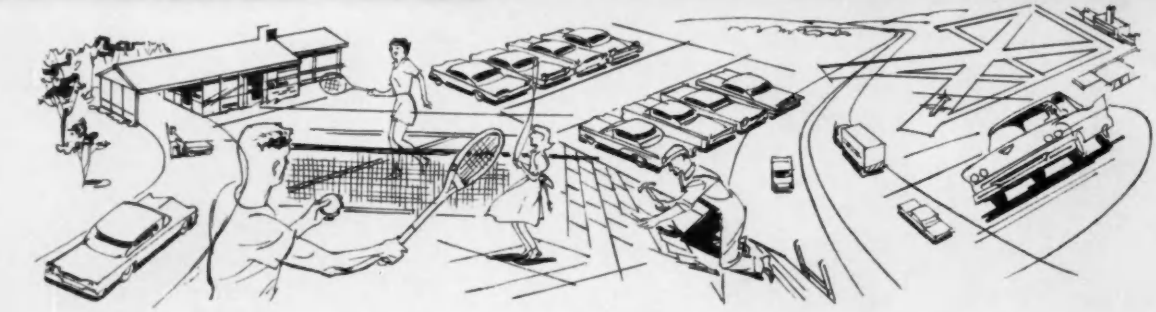
CONDITIONS DICTATE TREATMENT

The treatment required will be dictated by conditions and volume of water expected, as well as the relative cost of various installations that will provide the capacity needed. The following are recommended for consideration in the order of the amount of flow expected:

1. Two-layer trenches
2. Complete two-layer system

Cross-trenches must also be provided at the lower end of cuts and possibly at other locations on long grades. Cross-trenches should also be provided in sag vertical curves and on the low side of super-elevated curves, particularly on grades.

Structural section drainage must be designed after full and careful consideration of the soils present at each individual area. The drains must have sufficient capacity to drain the area quickly and this capacity must be protected by a properly designed filter barrier that prevents migration of fine materials into the drain. Further, close and constant inspection must be maintained during construction to assure that all portions of the drain are built as designed and function to serve the requirements of the design.



A GUIDE TO THE CONTENTS OF PREVIOUS ISSUES OF THE ASPHALT INSTITUTE QUARTERLY

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* NOTE: Issues of the Quarterly are available through any Institute office or member company (see page 15). The issues of April 1949, July 1949, October 1949, and July 1950, are out of stock at Institute headquarters (College Park, Maryland).

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